BIOLOGICAL EVALUATION OF GYPSY MOTH

at

APPALACHIAN TRAIL - PENNSYLVANIA

2008

Prepared by

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ABSTRACT

On December 9 & 10, 2008, USDA Forest Service personnel conducted a gypsy moth egg mass survey on the Appalachian Trail in Pennsylvania. The purposes of this survey were to determine gypsy moth population densities, assess the potential for defoliation and the need for treatment in 2009. Current populations are sufficient to cause heavy defoliation. Treatment is recommended to prevent defoliation, branch dieback and possible tree mortality which may impact Trail users.

METHODS

Gypsy moth survey plots were randomly selected based upon available host trees (oak species), size of sample area and uniformity between egg mass counts. Sample areas were based upon previous defoliation as reported by the Pennsylvania DNR and intersection with NPS boundaries. At each sample point, a $1/40^{th}$ acre fixed radius plot was established. The plots consisted of a tally of all the new (2008) egg masses observed on the overstory trees, understory vegetation, ground litter and duff. The total number of egg masses observed for each plot was multiplied by 40 to determine the number of egg masses per acre. Egg mass lengths were measured at the plots to determine the overall "health" of the existing population and as a measure of egg mass fecundity.

RESULTS

The location of the survey plots along with the proposed 2009 treatment areas are shown in Figure 1. The summarized results of the survey are presented in Table 1. In brief, egg mass densities ranged from less than 250 per acre to over 19,000 with the overall average of 3790 egg masses per acre. Egg mass lengths tended to be moderate to large in size, ranging from 20-40 mm and averaging 29 mm.

DISCUSSION

The egg mass survey results indicate that heavy defoliation is likely to occur in some areas.

This defoliation prediction is further supported when egg density is also used as a means of estimating gypsy moth population densities. Moore and Jones (1987) found that estimating the mean fecundity would increase the precision of gypsy moth density estimates and that a linear relationship exists between egg mass length and fecundity.

Further work by Liebhold et al., (1993) demonstrates that the product of the mean egg mass length (in mm) and egg mass density provides a more precise means of estimating

population densities and prediction defoliation. Using Liebhold's model, Table 1 shows how this information can be used to correlate the predicted defoliation of an area.

Predicting the extent of tree mortality that would occur after one year's defoliation is difficult, however, a stand of trees that is not stressed by other agents during or immediately following a single heavy defoliation will likely pull through with only minor branch dieback and minimal mortality. Trees that are defoliated in excess of 50 percent normally refoliate the same growing season. Such events cause the trees to expend valuable energy reserves to refoliate, and consequently cause the trees' health to deteriorate. Depending on the condition of the trees at the time of defoliation, reduced growth, mast abortion, branch dieback or in some cases tree mortality, has occurred following a single year of heavy defoliation. Should subsequent defoliation occur the following year, the impact is compounded. Trees that receive light defoliation (<50 percent) are not likely to refoliate and there is probably no significant impact other than a reduction in growth, reduction of mast and possibly some minor branch dieback.

Trees at greater risk are those that are presently stressed from other factors, such as soil compaction from roads, sidewalks, parking lots, machinery and/or heavy foot travel; over maturity; drought; shock due to recent timber cutting activities; previous year(s) defoliation; and other insect and disease related problems

The Allegheny National Forest (1988) and the West Virginia Division of Forestry (1997) provide examples of the potential tree mortality that can occur. On the Allegheny National Forest, untreated stands consisting of 40-80 percent oak, the average loss of basal area (mainly oaks) was about 16 percent (range 3-28 percent) following one year of defoliation and 26 percent (range 10-43 percent) after two consecutive years of defoliation. In a 1986 study area in eastern West Virginia where oak species accounted for 63-78 percent of the species composition, a loss of 25 percent of the total oak saw timber and 14 percent of the total oak pole timber occurred after one year of moderate to heavy defoliation. In these examples, droughty conditions likely contributed to the level of mortality.

Threshold (egg mass/acre)	Predicted defoliation	Objective
250	<30%	Nuisance abatement
251-500	30-50% (Light)	Prevent noticeable defoliation
>500	>50%	Prevent growth loss & tree mortality

Management Options

In 2009, three management options have been evaluated for managing gypsy moth populations on the Appalachian Trail. The intervention options are offered based upon the following two treatment objectives: 1) protect host tree foliage to prevent branch

dieback and tree mortality; and 2) reduce gypsy moth population below the treatment threshold. Each is discussed below.

No Action Option

It is possible that gypsy moth populations could collapse on their own due to the presence of nucleopolyhedrosis virus (NPV) or the more recently recognized fungal pathogen, *Entomophaga maimaiga*. In areas with defoliating levels of gypsy moth populations, viral epizooics generally manifest themselves after significant tree defoliation has already occurred. Gypsy moth populations will usually peak in 2-3 years once they reach levels and then collapse as a result of NPV or fungal activity. Residual populations following such a collapse will likely remain at low densities for 3-6 years before rebuilding to defoliating levels.

Although it is not possible to accurately assess such events with the defoliating levels and then collapse as a result of NPV or fungal activity. It is unlikely that a collapse will occur in 2009 prior to a significant defoliation event.

Large numbers of gypsy moth caterpillars and defoliation has been shown to impact competing native herbivore arthropods. Sample et al., (1996) showed short-term impacts of both species richness and abundance occurred following light to moderate defoliation events in study plots in West Virginia. It is likely that impacts would be greater as the size of the area and intensity of defoliation increases and be more long term, should extensive tree mortality occur.

Should this option be selected, it is likely that widespread heavy defoliation will occur.

Microbial Insecticide Option

***Btk*:** The only biological insecticide currently registered and commercially available for gypsy moth control is the microbial insecticide *Bacillus thuringienis* variety *kurstaki (Btk)*. This insecticide is available through several manufacturers and has been used extensively in suppression projects throughout the U.S. in both forested and residential areas. *Btk* is a bacterium that acts specifically against lepidopterous larvae as a stomach poison and therefore must be ingested. The major mode of action is by mid-gut paralysis which occurs soon after feeding. This results in a cessation of feeding, and death by starvation. *Btk* is persistent on foliage for about 7-10 days.

Btk has been shown to impact other non-target caterpillars that are actively feeding at the time of treatment. An example of the potential impacts is provided by a study conducted by Miller (1990) in Oregon and Samples, et al., (1996) in West Virginia. Miller's study involved a large scale (5,000 acres) eradication program where three consecutive applications of *Btk* were applied within a single season. On Garry oak, Miller found that species richness was significantly reduced in treated areas during all 3 years of the study while the total number of immature native Lepidoptera rebounded after the second year. In the Sample study, the areas treated with *Btk* were 50 acre plots and only a single

treatment applied. Here too, both species richness and the total numbers of native macro-lepidopterous caterpillars and adults were reduced but only for less than 1 year. The difference in duration of the impacts between these studies is probably the result of the number of treatment applications applied and the size of the treatment area involved.

Btk formulations are available as flowable concentrates, wettable powders, and emulsifiable suspensions. The normal application rates range from 24-36 billion international units (BIUs) per acre in a single or double application. *Btk* can be applied either undiluted or mixed with water for a total volume of ½ -1 gallon per acre. With proper application, foliage protection and some degree of population reduction can be expected with one application and with two applications both foliage protection and a greater degree of population reduction are likely.

Because *Btk* is a biological insecticide, the degree of population reduction varies and may depend on, at least in part, the selected application rate, relative health of the population (building vs. declining), population densities, weather (rain and temperature), the feeding activity of the larvae following treatment, and the actual potency of the product.

Gypchek: A second microbial insecticide that is registered and available in limited quantities is the formulated nucleopolyhedrosis virus called Gypchek. This product is not available commercially but is produced in limited quantities by a cooperative effort of the USDA Forest Service and the Animal Plant Health Inspection Service (APHIS). The active ingredient in Gypchek formulations has a very narrow host range (lymnatriids) and occurs naturally in gypsy moth populations. Normally the virus reaches epizootic proportions when gypsy moth populations reach high densities as a result of increased transmission within and between gypsy moth generations. The application of Gypchek to gypsy moth populations simply expedites this process by increasing the exposure of the virus at an earlier stage. Healthy, feeding gypsy moth caterpillars become infected by ingesting contaminated foliage and soon stop feeding and die.

The efficacy of Gypchek treatments to reduce gypsy moth populations has been quite variable. Because of the short period of viral activity on foliage (3-5 days) as well as other biological factors such as feeding activity and weather conditions, it has been difficult at best to project treatment efficacy. Most often foliage protection can be achieved but significant reductions in gypsy moth densities do not always occur. Should inadequate population reduction occur, areas would need to be treated again the following year.

The normal application rate of Gypchek is 4×10^{11} occlusion bodies (OB's) per acre applied in a single application or 2×10^{11} OB's per acre applied in a double application. Due to the limited supply, priority is first given to state and federal cooperators that need to deal with federally listed threatened and endangered species associated with gypsy moth treatments.

Alternatives

With the previously described options in mind, the following alternatives are offered:

Alternative 1. - No action.

Alternative 2. - One aerial application of *Btk* at the rate of 36 BIUs in a total mix of ½-¾ gallon per acre.

Alternative 3. - One aerial application of Gypchek at the rate of 4×10^{11} OB's in a total mix of 1 gallon per acre.

RECOMMENDATIONS

To protect tree foliage, prevent mast failure, prevent branch dieback and possible tree mortality, our recommendation is alternative 2 (a single application of *Btk*).

This recommendation is based on the following considerations:

1) It is likely that a single application of *Btk* will provide adequate foliage protection and a population reduction thereby minimizing tree stress and mortality.
2) Gypchek is less likely to provide adequate foliage protection on a significant population reduction than Btk.

PROPOSED TREATMENT AREAS

Based upon survey results (areas with gypsy moth populations in excess of 1000 egg masses per acre), previous defoliation, the intersection of federally managed lands, and protection priorities indicated by the National Park Service the following treatment areas are proposed:

Proposed treatment area	Survey location from Fig. 2a-2f	Acres proposed	GM density
1	A5	28	2760
2	A9	16	1071
3	A11	54	1020
4	A15	26	14577
5	A16	20	3974
6	A23	279	19454
7	A25	75	10403
8	A31	34	4769
9	A32	7	3640

Maps of these proposed areas are included.

REFERENCES

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				Egg Masses Counts			Calculations		Old		Egg Mass Length			Ave
	Location	ID	Plot	old	new	crown	Proportion new	Density	Proportion Old	Density Old	EM1	EM2	EM3	
A	Buena Vista Springs	1	A1	0	1	0	1.00	40	0	0				
A	Buena Vista Springs	2	A2	0	7	0	1.00	280	0	0	42	35	41	39
A	Mount Union	3	A3	0	3	5	1.00	320	0	0	30	30	30	30
							Year	**2009**		**2008**		**EM Average**		35
							Average Egg Mass Density	**213**		0		**std dev**		7
							std dev	151		0		std err		5
							std err	87		0				
							Length X Density	7396						
							Predicted Percent Defoliation	**20**						
B	Michaux State Forest	4	A5	0	6	30	1.00	1440	0	0	0	0	0	0
B	Michaux State Forest	5	A5-B	0	42	60	1.00	4080	0	0	40	40	40	40
							Year	**2009**		**2008**		**EM Average**		20
							Average Egg Mass Density	**2760**		0		**std dev**		28
							std dev	1867		0		std err		20
							std err	1320		0				
							Length X Density	55200						
							Predicted Percent Defoliation	**49**						
C	Hunter's Run	6	A9	0	13	14	1.00	1080	0	0	30	30	30	30
C	Hunter's Run	7	A9-A	0	4	0	1.00	160	0	0				
C	Hunter's Run	8	A9-B	3	40	10	0.93	1972	0	148				
							Year	**2009**		**2008**		**EM Average**		30
							Average Egg Mass Density	**1071**		49		**std dev**		#DIV/0!
							std dev	906		85		std err		#DIV/0!
							std err	523		49				
							Length X Density	32121						
							Predicted Percent Defoliation	**34**						

				Egg Masses Counts			Calculations		Old		Egg Mass Length			Ave
	Location	ID	Plot	old	new	crown	Proportion new	Density	Proportion Old	Density Old	EM1	EM2	EM3	
D	Upper Mill	9	A11	0	8	10	1.00	720	0	0	40	40	40	40
D	Upper Mill	10	A11-A	0	20	13	1.00	1320	0	0	.	.	.	.
							Year	**2009**		**2008**		**EM Average**		40
							Average Egg Mass Density	**1020**		0		**std dev**		#DIV/0!
							std dev	424		0		std err		#DIV/0!
							std err	300		0				
							Length X Density	40800						
							Predicted Percent Defoliation	**40**						
E	Donnellytown (Blue MT	11	A13	0	1	0	1.00	40	0	0	.	.	.	.
E	Little Mtn	12	A15	4	116	257	0.97	14577	0	503	21	19	42	27
E	SGL 170	13	A16	11	41	74	0.79	3974	0	1066	40	36	21	32
							Year	**2009**		**2008**		**EM Average**		30
							Average Egg Mass Density	**6197**		523		**std dev**		4
							std dev	7519		533		std err		2
							std err	4341		308				
							Length X Density	184879						
							Predicted Percent Defoliation	**83**						
F	Peter's Mtn (Victoria Fu	14	A22	0	5	1	1.00	240	0	0	25	25	25	25
F	Peter's Mtn (Victoria Fu	15	A22-A	0	5	58	1.00	2520	0	0	30	30	30	30
F	Clark's Creek (DeHart	16	A23	5	82	429	0.94	19454	0	1186	20	25	23	23
							Year	**2009**		**2008**		**EM Average**		26
							Average Egg Mass Density	**7405**		395		**std dev**		4
							std dev	10497		685		std err		2
							std err	6060		395				
							Length X Density	191697						
							Predicted Percent Defoliation	**84**						

				Egg Masses Counts			Calculations		Old		Egg Mass Length			Ave
	Location	ID	Plot	old	new	crown	Proportion new	Density	Proportion Old	Density Old	EM1	EM2	EM3	
G	Swatara State Park (In	17	A25	4	55	220	0.93	10403	0	757	36	41	22	33
G	Swatara State Park (C	18	A31	2	80	37	0.98	4644	0	116	30	30	30	30
G	Swatara State Park (C	19	A31-A	1	75	48	0.99	4895	0	65	30	30	30	30
G	Swatara State Park (A	20	A32	0	59	32	1.00	3640	0	0	30	30	30	30
							Year	**2009**		**2008**		**EM Average**		31
							Average Egg Mass Density	**5896**		234		**std dev**		2
							std dev	3054		351		std err		1
							std err	1763		203				
							Length X Density	181287						
							Predicted Percent Defoliation	**82**						
								2009		**2008**				
						All Plots								
							Average Egg Mass Density	3790		192		**EM Average**		29
							std dev	5227		375		**std dev**		10
							std err	1169		84		std err		2
								111088						
							Length X Density	111088						
							Predicted Percent Defoliation	**79**						

Figure 1

Gypsy Moth Egg Mass Survey Plot Locations on the Appalachian Trail in Pennsylvania, December 2008

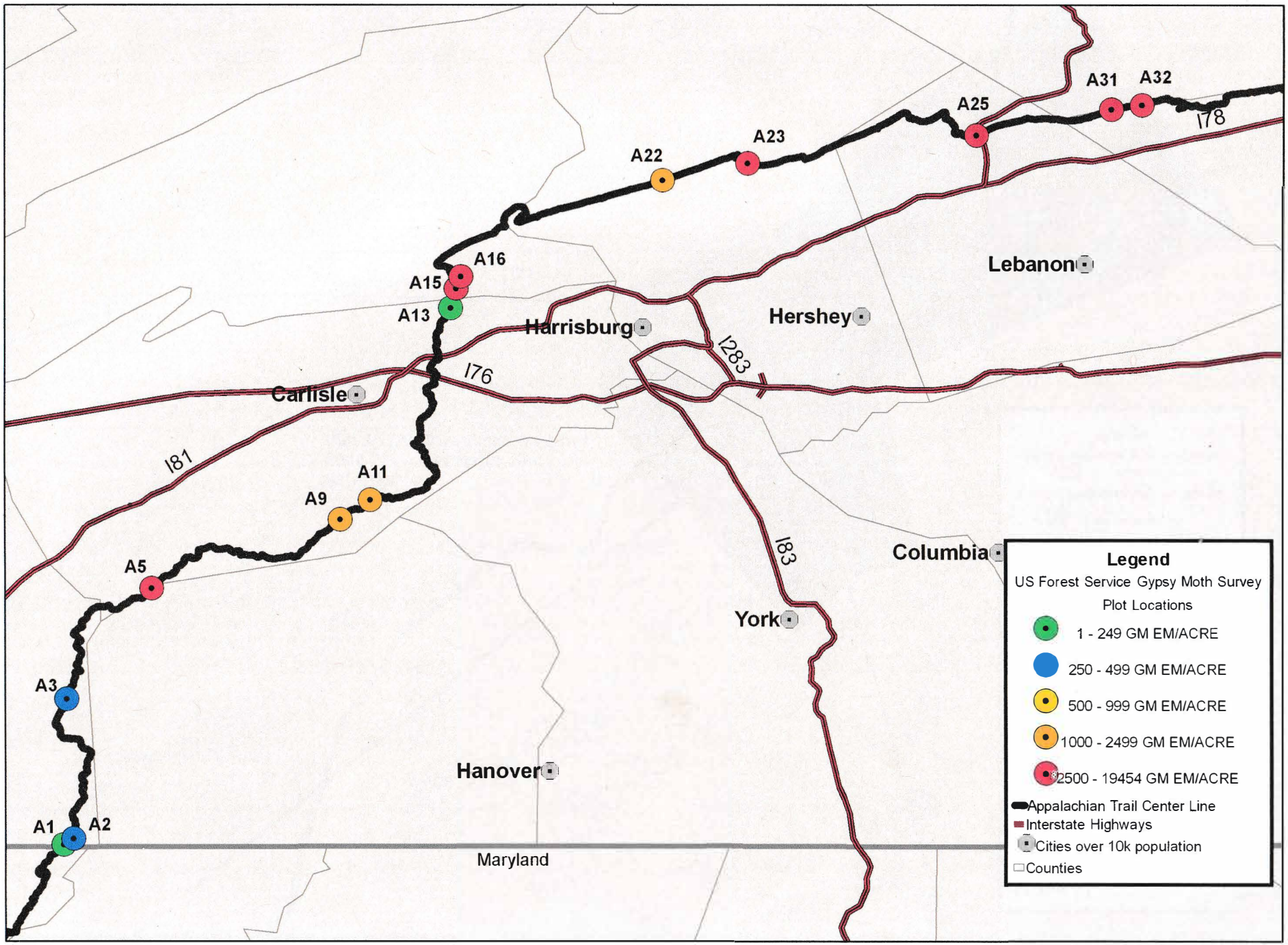
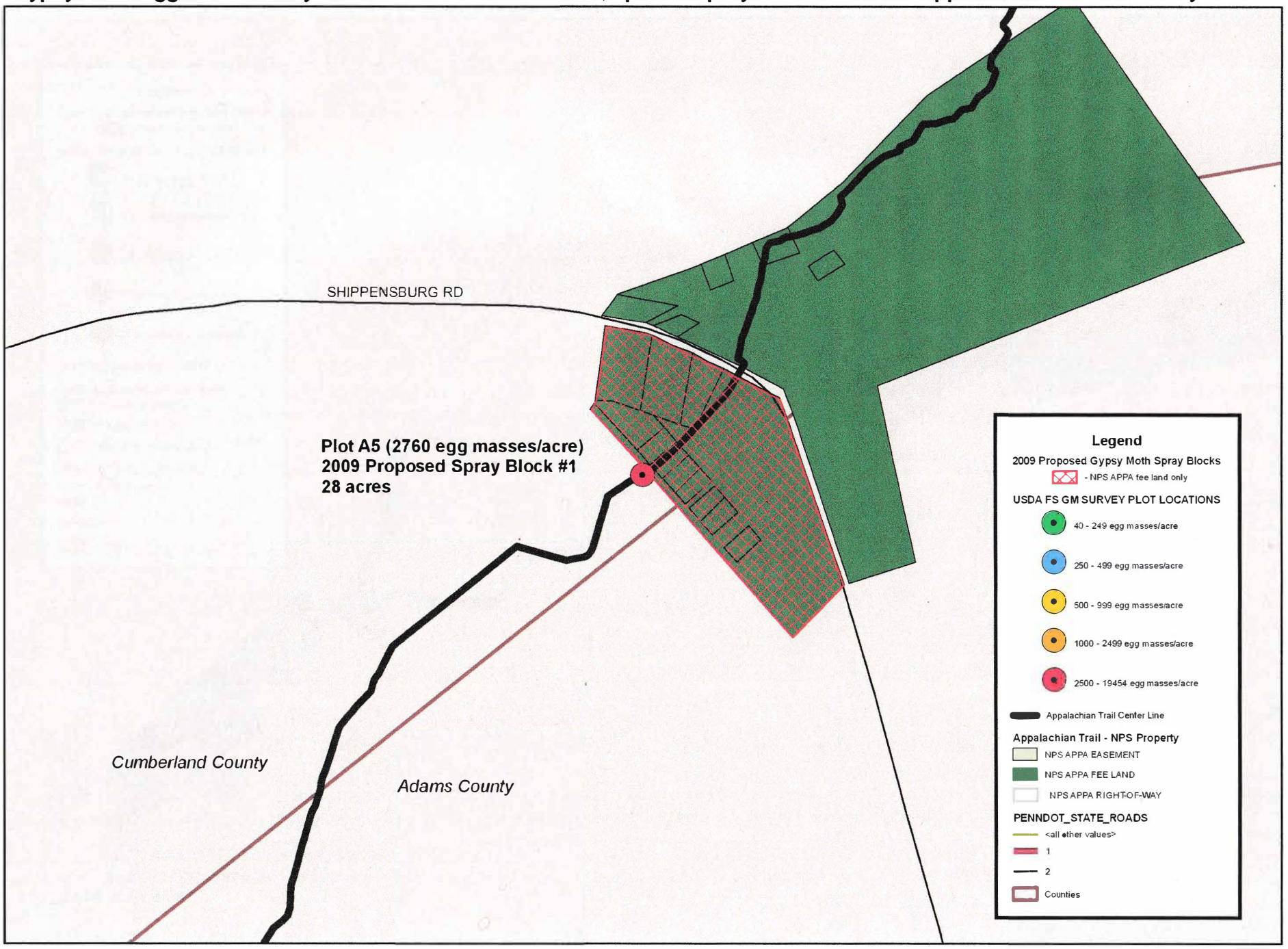


Figure 1

USDA Forest Service-FHP
Morgantown, WV KDF 12/16/08

Gypsy Moth Egg Mass Survey Plot Location A5 and 2009 Proposed Spray Block #1 on the Appalachian Trail in Pennsylvania



USDA Forest Service-FHP
Morgantown, WV KDF 3/5/09

Figure 2a

Fi[illegible] 2

Gypsy Moth Egg Mass Survey Plot Locations A9 and A11 and 2009 Proposed Spray Blocks #2 and #3 on the Appalachian Trail in Pennsylvania

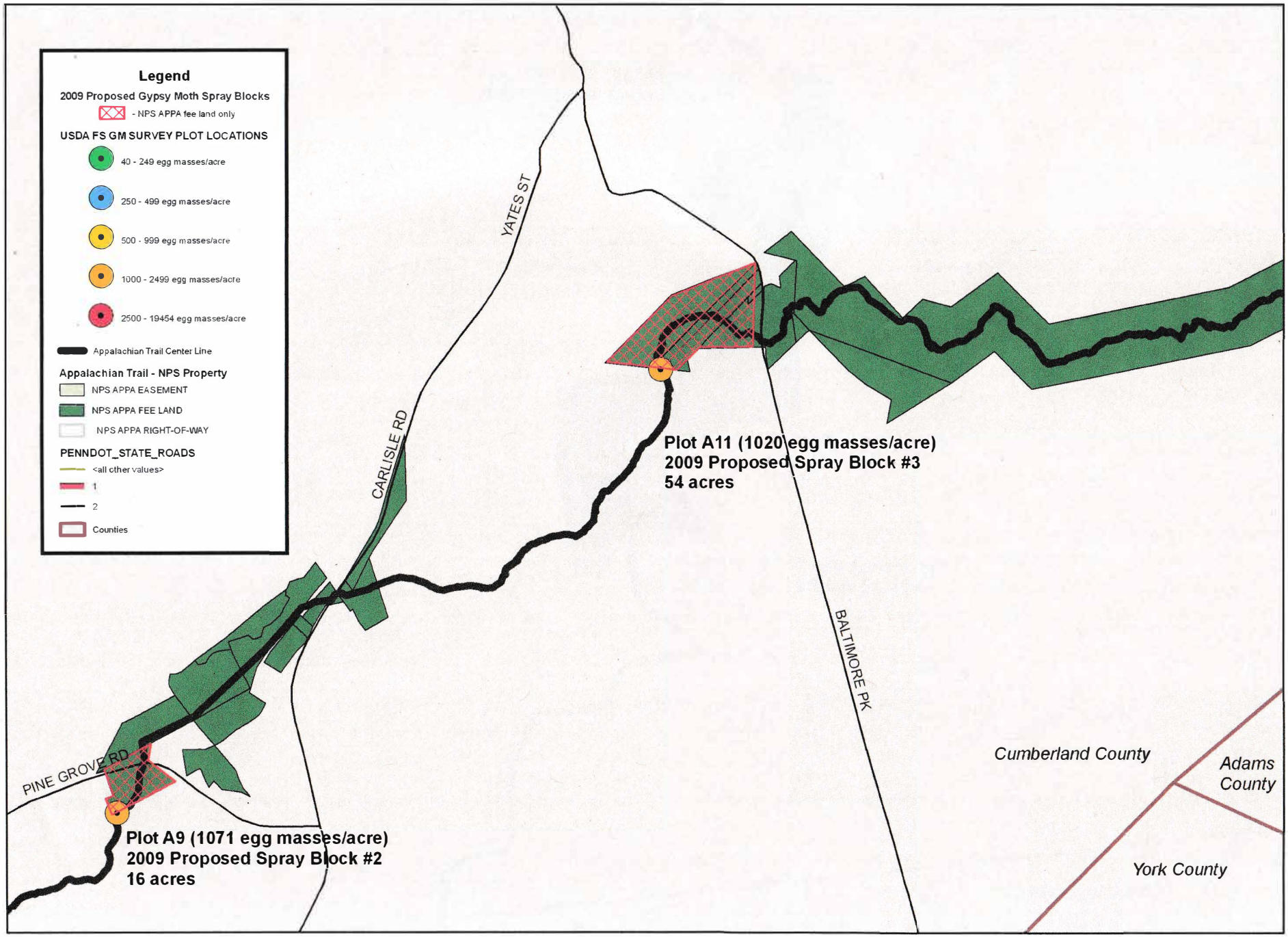


Figure 2b

USDA Forest Service-FHP
Morgantown, WV KDF 3/5/09

Figure 2c

Gypsy Moth Egg Mass Survey Plot Locations A15 and A16 and 2009 Proposed Spray Blocks #4 and #5 on the Appalachian Trail in Pennsylvania

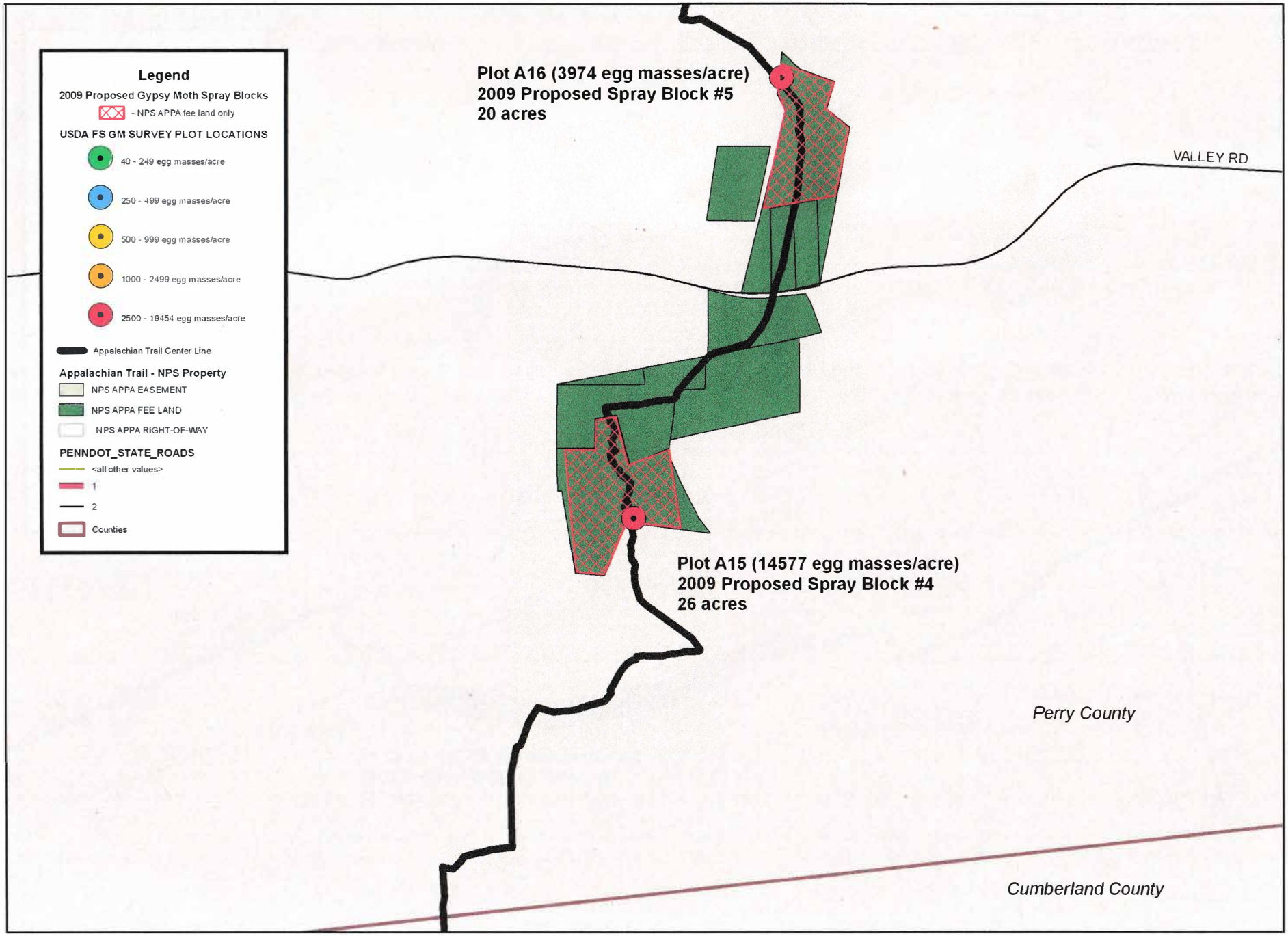


Figure 2c

USDA Forest Service-FHP
Morgantown, WV KDF 3/5/09

Gypsy Moth Egg Mass Survey Plot Location A23 and 2009 Proposed Spray Block #6 on the Appalachian Trail in Pennsylvania

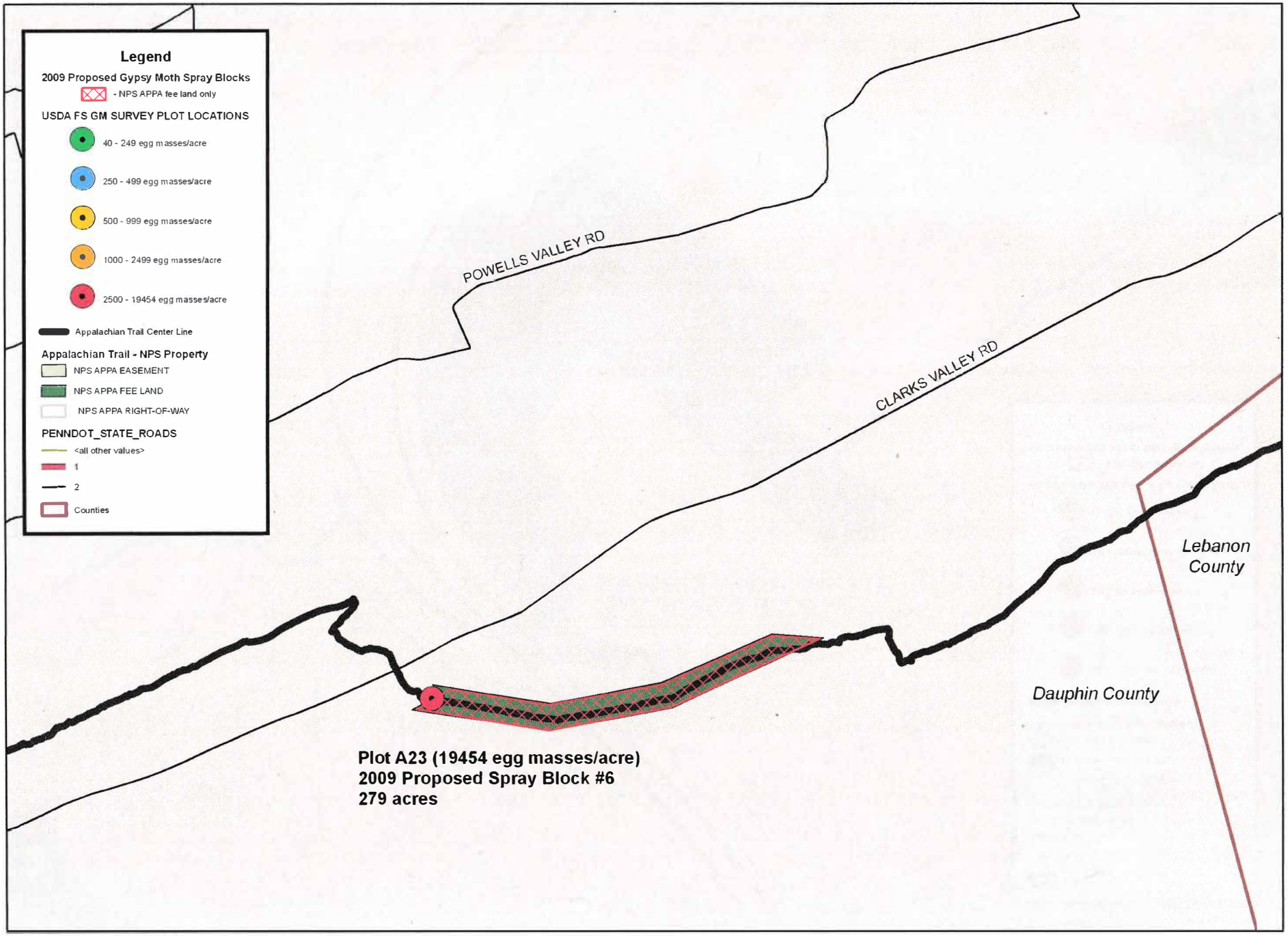
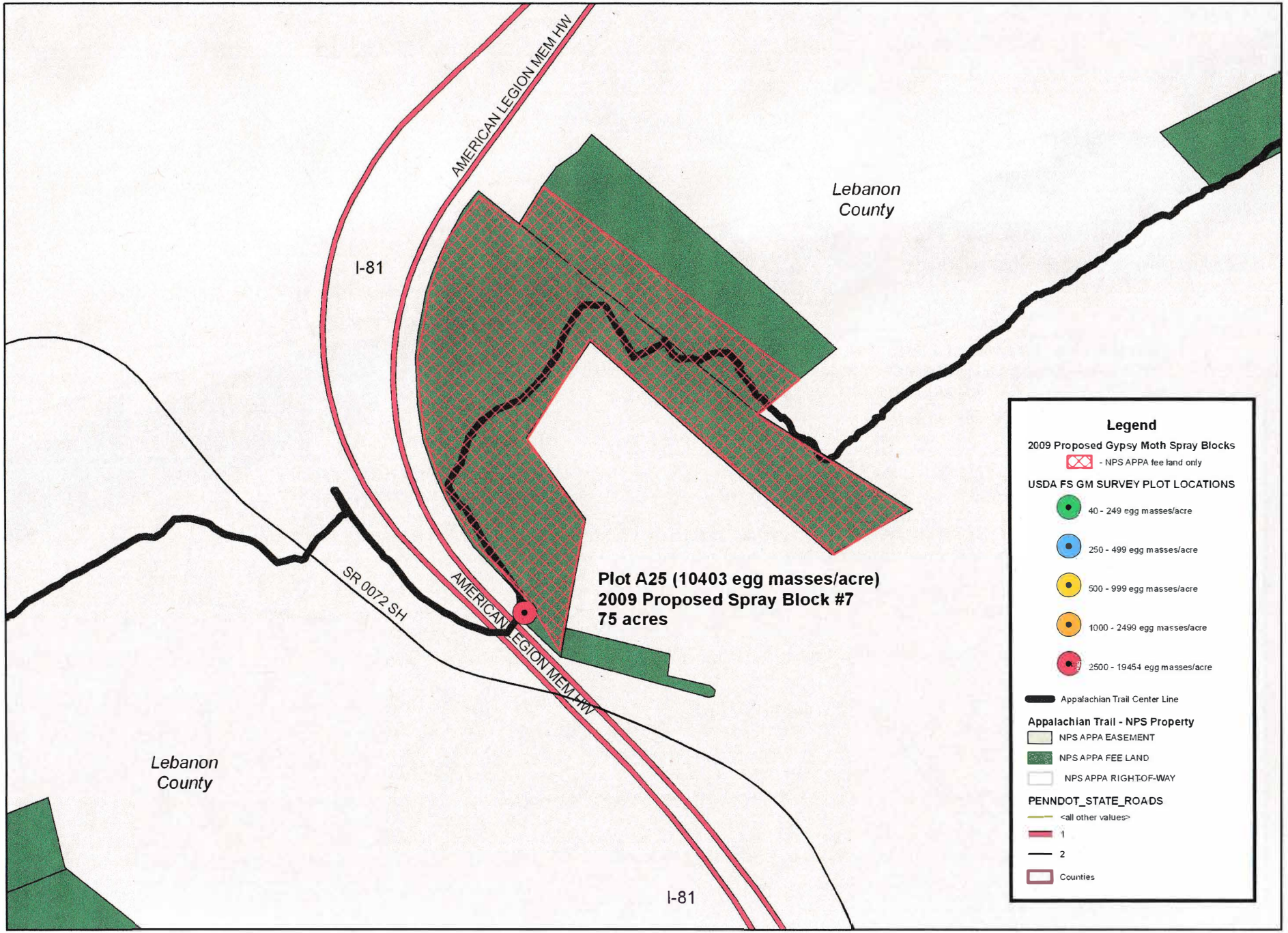


Figure 2d

USDA Forest Service-FHP
Morgantown, WV KDF 3/5/09

Figure 2e

Gypsy Moth Egg Mass Survey Plot Location A25 and 2009 Proposed Spray Block #7 on the Appalachian Trail in Pennsylvania



USDA Forest Service-FHP
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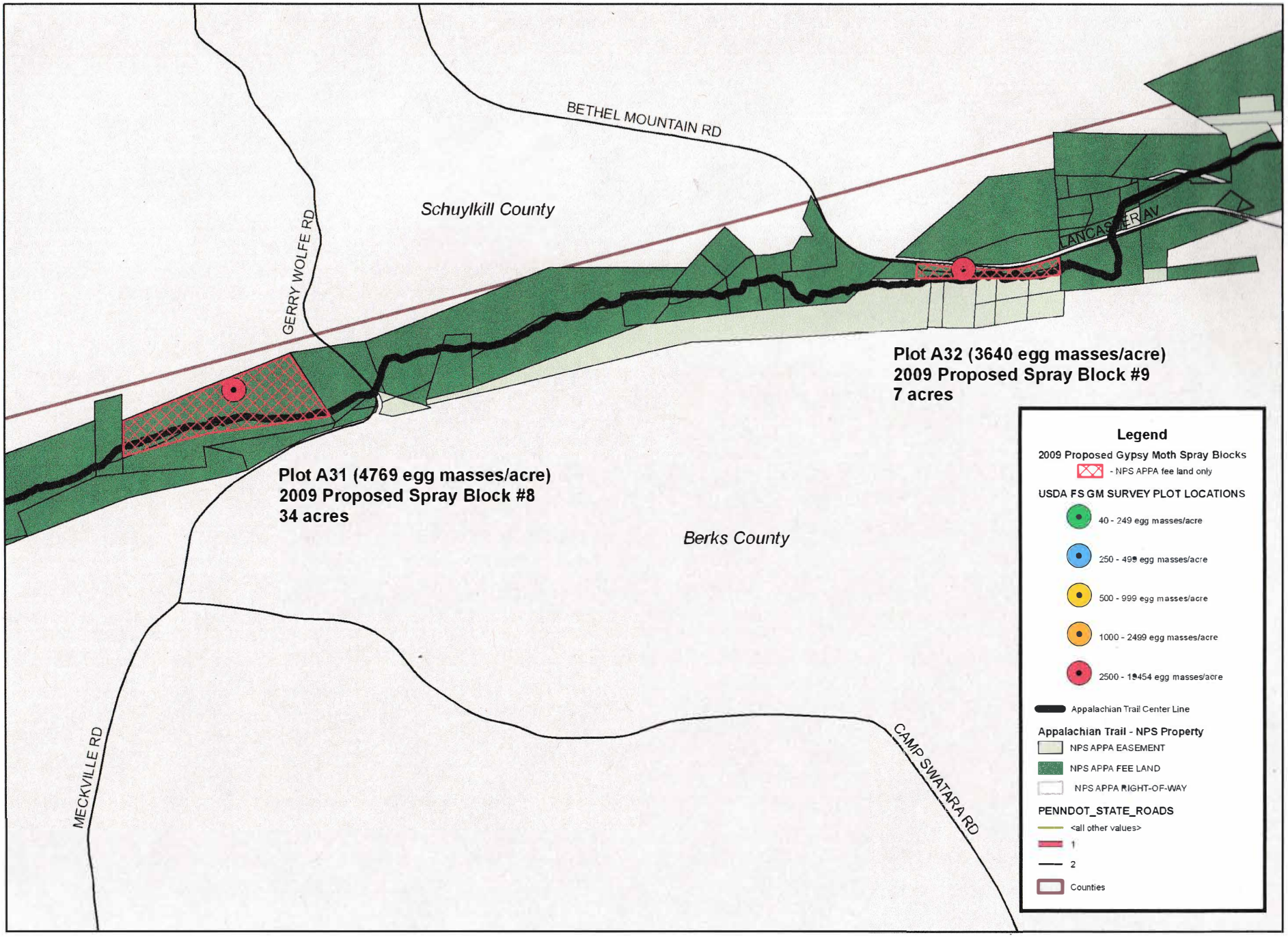
Figure 2e

Figure 2f

Gypsy Moth Egg Mass Survey Plot Locations A31and A32 and 2009 Proposed Spray Blocks #8 and #9 on the Appalachian Trail in Pennsylvania



USDA Forest Service-FHP
Morgantown, WV KDF 3/5/09